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PATENT & TRADEMARK OFFICE

Patent
Attorney's Docket No. 015290-457

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

Jerome S. HUBACEK et al.

Application No.: 09/749,916

Filed: December 29, 2000

For: ELECTRODE FOR PLASMA PROCESSES AND METHOD FOR MANUFACTURE AND USE THEREOF

Group Art Unit: 1763

Examiner: L.A. Mulero

Confirmation No.: 6834

DECLARATION BY JEROME S. HUBACEK UNDER 37 C.F.R. § 1.132

Commissioner for Patents
PO Box 1450
Alexandria, Virginia 22313-1450

Sir:

I, Jerome S. Hubacek, hereby state as follows:

1. I am an inventor of the subject matter claimed in the above-identified application.

2. Tests were performed under my supervision using low resistivity, single crystal silicon showerhead electrodes in a plasma reaction chamber. The showerhead electrodes had a plurality of gas passages (outlets) with a diameter of 0.025 inch arranged to distribute a process gas in the reaction chamber during use of the electrodes. The showerhead electrodes had thicknesses of 0.15 inch, 0.18 inch, 0.25 inch, and 0.35 inch. The showerhead electrodes were bonded to a graphite support member by an elastomeric joint. Power levels of 1000 watts, 2000 watts, and 3000 watts were applied to each of the showerhead electrodes. A power level of 4000 watts was also applied to the showerhead electrodes having a thickness of 0.25 inch and 0.35 inch. The center-to-edge temperature

gradients of the showerhead electrodes having a thickness of 0.15 inch, 0.18 inch, and 0.35 inch were modeled based on temperature measurements made for the showerhead electrode having a thickness of 0.25 inch. The test results are plotted in the graph in attached Appendix A. The graph shows that at each applied power level, the center-to-edge temperature gradient decreases as the showerhead electrode thickness increases. For example, at an applied power level of 3000 watts, increasing the electrode thickness from 0.25 inch to 0.30 inch reduces the center-to-edge temperature gradient by about 15% (on the centigrade scale). Increasing the electrode thickness from 0.25 inch to 0.35 inch at the same applied power level reduces the center-to-edge temperature gradient by about 35%.

3. The claimed showerhead electrode allows longer production times before replacement is needed. Increasing the showerhead electrode thickness unexpectedly provides better thermal uniformity while increasing the lifetime of the electrode (i.e., the number of RF hours that it can be used). The thicker electrode allows an increase in the maximum amount of power that the showerhead electrode can be operated at without failure. At a set power level, increasing the showerhead electrode thickness reduces the center-to-edge thermal gradient of the electrode (see Appendix A), which surprisingly reduces the probability of cracking of the electrode, especially at high power levels (e.g., 4000 watts).

4. The showerhead electrode thickness versus the power level applied to the electrode was measured, and the test results are plotted in the graph in attached Appendix B. The region above line A represents the experimentally determined operating range in which the probability of electrode cracking is low, while the region below line A represents the operating range in which the probability of electrode cracking is high. Extrapolation of line A to greater electrode thickness values shows that showerhead electrodes having a thickness of 0.30 inch or greater can be operated at significantly higher power levels than electrodes having a thickness of 0.25 inches or less.

5. Increasing the showerhead electrode thickness while using the same diameter gas passages in the electrode surprisingly reduces particle contamination of processed wafers. The increased length of the gas passages also increases the gas pressure behind the electrode. Showerhead electrodes having a thickness of 0.30 inch and larger reduce deposition of polymer particles behind the electrode, as compared to the electrodes having a thickness of 0.15 inch, 0.18 inch, and 0.25 inch. The claimed electrode can provide beneficial reduction in particle defects.

6. The claimed thick showerhead electrode provides better RF coupling than thinner showerhead electrodes. Because increasing the thickness of the showerhead electrode decreases the electrical resistance of the electrode, ohmic losses in the electrode can be reduced. Coupling of radio frequency (RF) power to the plasma reactor can be enhanced. Reducing the impedance path of the RF results in a higher etch rate of substrates in the plasma reactor at a set power level applied to the electrode, and surprisingly the etch uniformity was as good as, or better than, that of a lower resistance electrode (e.g., a thinner electrode). Reducing the electrode resistance also improves plasma confinement in the plasma reactor. Such performance benefits are highly desirable in semiconductor processing.

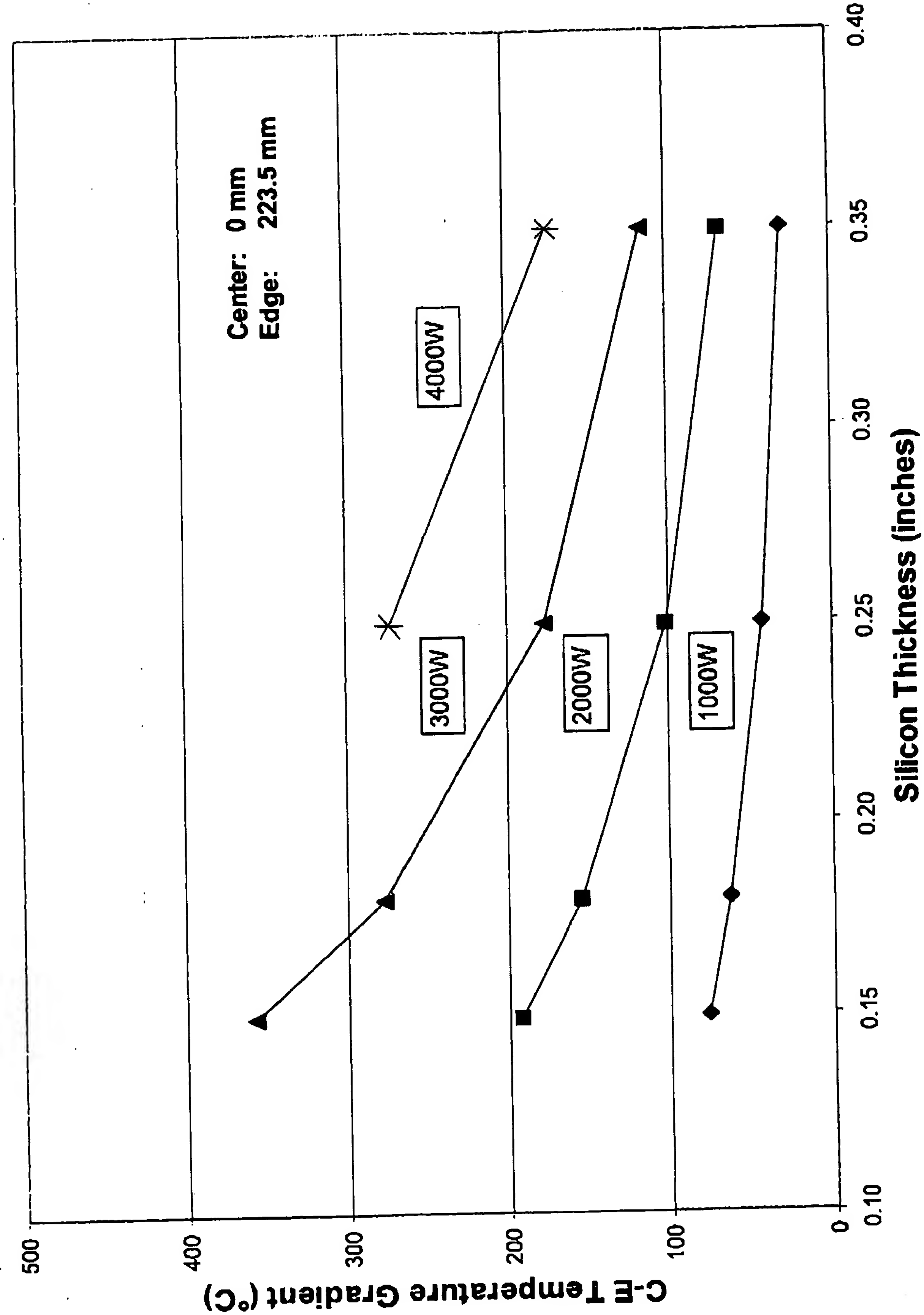
I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: 8/14/03

Jerome S. Hubacek

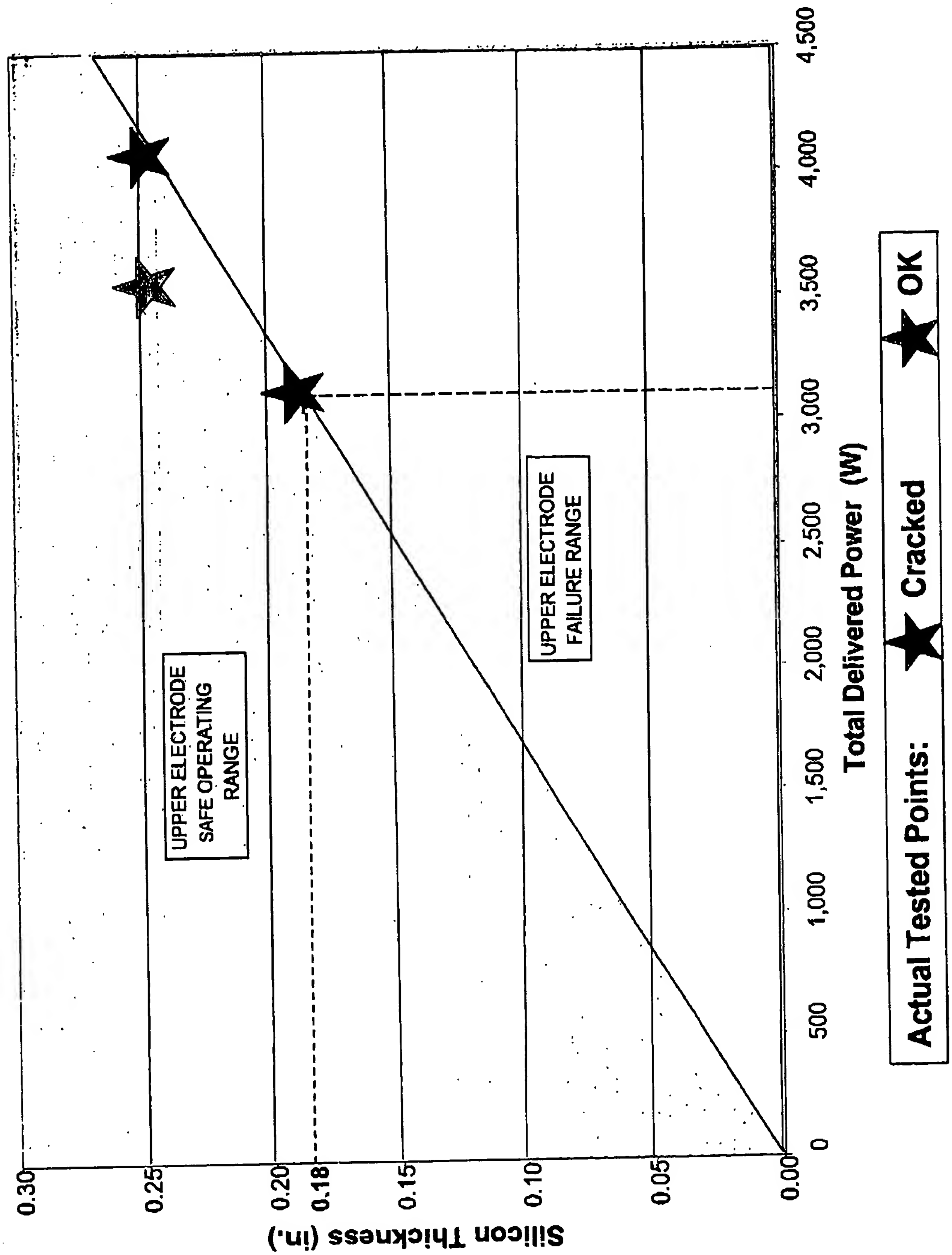
(05/02)

TOTAL P.04



Center: 0 mm
Edge: 223.5 mm
4000W
3000W
2000W
1000W
C-E Temperature Gradient (°C)
0
100
200
300
400
500
Silicon Thickness (inches)
0.10
0.15
0.20
0.25
0.30
0.35
0.40

Appendix B



Silicon Thickness (in.)
0.30
0.25
0.20
0.18
0.15
0.10
0.05
0.00
Total Delivered Power (W)
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
UPPER ELECTRODE SAFE OPERATING RANGE
UPPER ELECTRODE FAILURE RANGE
Actual Tested Points:
Cracked
OK

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Date: ______________________ ______________________________
Jerome S. Hubacek